Chapter 3

Statewide Criteria Pollutant Emission and Air Quality Trends and Forecasts

Introduction

Emission Trends and Forecasts

The most current emissions data available are from 2000. Any data prior to this year are derived from historical emissions data. Current year data and future year data are forecasted from the 2000 base year and control measures reported through September 2000. Forecasts take into account emissions data, projected growth rates, and future control measures to calculate emissions in future years.

Statewide Emissions (tons/day, annual average)								
	1975	1980	1985	1990	1995	2000	2005	2010
NO_x	4761	4949	4950	4929	4207	3570	3007	2573
ROG	6839	6513	6170	4868	3908	3273	2810	2563
PM_{10}	1864	2018	2004	2240	2177	2313	2466	2612
CO	43210	39701	40427	35062	26870	20591	15801	12944

Table 3-1

On a statewide basis, emissions of NO_x increased slightly between 1975 and 1985, but are declining between 1985 and 2010. Emissions of ROG are decreasing steadily between 1975 and 2010. In addition to being ozone precursors, both NO_x and ROG are secondary contributors to PM_{10}. In contrast to NO_x and ROG, direct PM_{10} emissions are increasing from 1995 to 2010, primarily due to increases in the number of vehicle miles traveled (VMT) on paved and unpaved roads. These VMT estimates are reported by Councils of Governments and local and regional air pollution control agencies. As a percent of area-wide sources, paved road dust accounts for 16 percent of the total in 1975, rising to 19 percent in 1995, and remaining steady at that level until 2010. As a percent of area-wide sources, unpaved road dust accounts for 28 percent of the total in 1975, rising to 32 percent of the total in 1995, and remaining steady at that level until 2010.

Emissions of CO have decreased since 1985. The recent decrease in NO_x, ROG, and CO is occurring even with increases of VMT and population levels.

Statewide Population and VMT

Airborne pollutants result in large part from human activities, and growth generally has a negative impact on air quality. California is fortunate in that it boasts the world's most progressive emission controls. These controls have resulted in significant air quality improvements, despite substantial growth.

During 1980 through 1999, statewide peak 1-hour ozone values decreased 53 percent, and carbon monoxide values dropped 35 percent. These air quality improvements occurred at the same time the State's population increased 43 percent and the daily number of vehicle miles traveled (VMT) increased 87 percent (1980 to 2000). Ambient annual geometric mean PM_{10} values in the non-desert areas also show improvement -- a 21 percent decrease from 1988 to 1999. While the air quality improvements are impressive, additional emission controls will be needed to offset future growth.

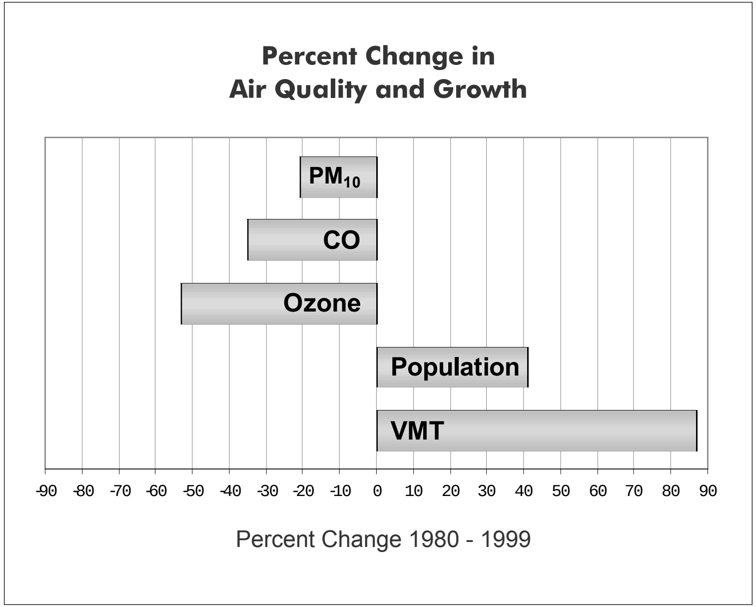

Figure 3-1

Ozone

Emission Trends and Forecasts - Ozone Precursors

NO_x Emission Trends and Forecasts

NO_x emission standards for on-road motor vehicles were introduced in 1971 and followed in later years by the implementation of more stringent standards and the introduction of three-way catalysts. NO_x emissions from on-road motor vehicles have declined by over 30 percent from 1990 to 2000, and NO_x emissions are projected to decrease by an additional 40 percent between 2000 and 2010. This has occurred as vehicles meeting more stringent emission standards enter the fleet, and all vehicles use cleaner burning gasoline and diesel fuel or alternative fuels. Stationary source NO_x emissions dropped by over 40 percent between 1980 and 1995. This decrease has been largely due to a switch from fuel oil to natural gas and the implementation of combustion controls such as low-NO_x burners for boilers and catalytic converters for both external and internal combustion stationary sources. State Implementation Plan (SIP) and conformity inventory forecasts may differ from the forecasts presented in this almanac. For additional information on these forecasts, please refer to the ARB SIP web page at *www.arb.ca.gov/sip/siprev1.htm*.

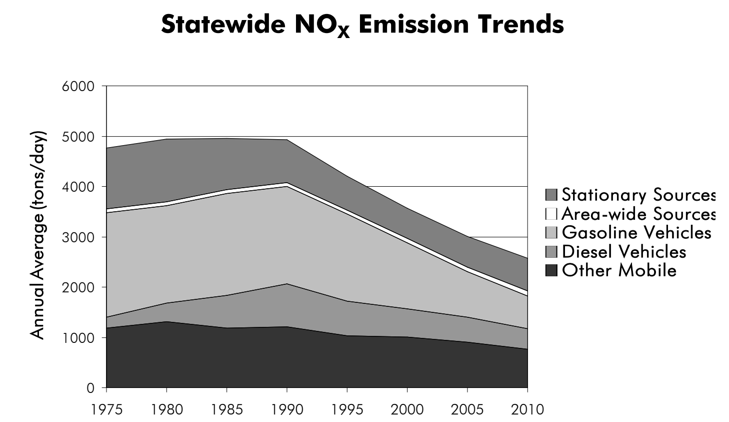

Figure 3-2

ROG Emission Trends and Forecasts

ROG emissions in California are projected to decrease by over 60 percent between 1975 and 2010, largely as a result of the State's on-road motor vehicle emission control program. This includes the use of improved evaporative emission control systems, computerized fuel injection, and engine management systems to meet increasingly stringent California emission standards, cleaner gasoline, and the Smog Check program. ROG emissions from other mobile sources are projected to decline between 1995 and 2010 as more stringent emission standards are adopted and implemented. Substantial reductions have also been obtained for area-wide sources through the vapor recovery program for service stations, bulk plants, and other fuel distribution operations. There are also on-going programs to reduce overall solvent ROG emissions from coatings, consumer products, cleaning and degreasing solvents, and other substances used within California. Again, State Implementation Plan (SIP) and conformity inventory forecasts may differ from the forecasts presented in this almanac. For additional information on these forecasts, please refer to the ARB SIP web page at *www.arb.ca.gov/sip/siprev1.htm*.

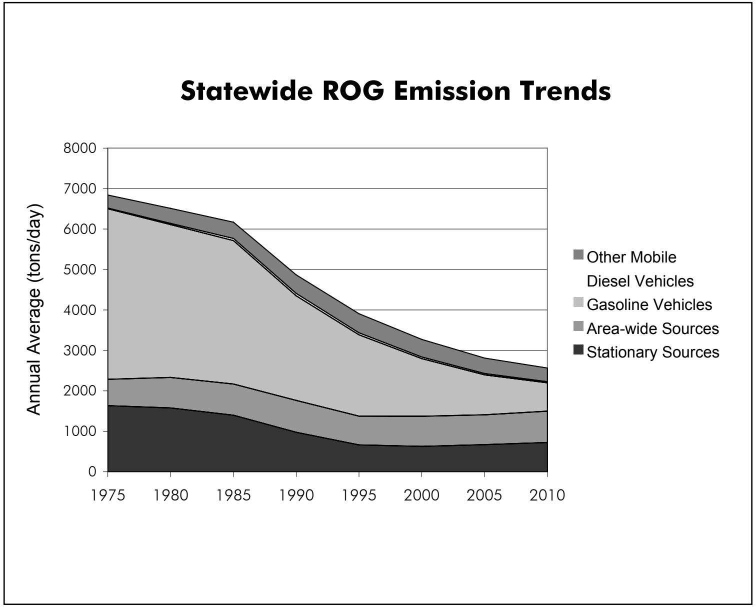

Figure 3-3

Emission Trends and Forecasts - Ozone Precursors

NOx Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***4761***	***4947***	***4950***	***4929***	***4207***	***3570***	***3007***	***2573***
Stationary Sources	1209	1249	1010	849	673	603	607	644
Area-wide Sources	72	81	84	81	85	94	99	104
On-Road Mobile	2299	2310	2670	2787	2413	1862	1397	1061
Gasoline Vehicles	2074	1933	2024	1934	1728	1301	902	647
Diesel Vehicles	224	378	647	853	686	561	495	415
Other Mobile	1181	1306	1185	1211	1035	1011	904	763

Table 3-2

ROG Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***6839***	***6513***	***6170***	***4868***	***3908***	***3273***	***2810***	***2563***
Stationary Sources	1634	1579	1397	978	666	629	671	724
Area-wide Sources	652	753	774	786	709	744	739	774
On-Road Mobile	4232	3809	3596	2645	2060	1463	1019	729
Gasoline Vehicles	4215	3779	3543	2585	2011	1426	985	700
Diesel Vehicles	17	30	53	60	49	37	34	28
Other Mobile	322	372	403	459	474	437	381	337

Statewide Air Quality - Ozone

Air quality as it relates to ozone has improved greatly in all areas of California over the last 20 years, despite significant growth. The statewide trend, which reflects values for the South Coast Air Basin, shows the maximum peak 1-hour indicator declined 53 percent from 1980 to 1999. During this same time period, the population grew by 43 percent and the number of vehicle miles traveled each day was up more than 85 percent. Motor vehicles are the largest source category of ozone precursor emissions, and reducing their emissions will continue to be the cornerstone of California's ozone control efforts. New vehicles must meet the ARB's low emission vehicle standards, which equate to about 95 percent fewer smog-forming emissions than vehicles produced in the 1970s. However, increases in population and driving are partially offsetting the benefits of cleaner vehicles. In addition to motor vehicle controls, the ARB is establishing controls for other sources of ozone precursor emissions, such as consumer products. The ARB and other agencies are also looking at new and more efficient ways of doing business and implementing incentives to improve air quality.

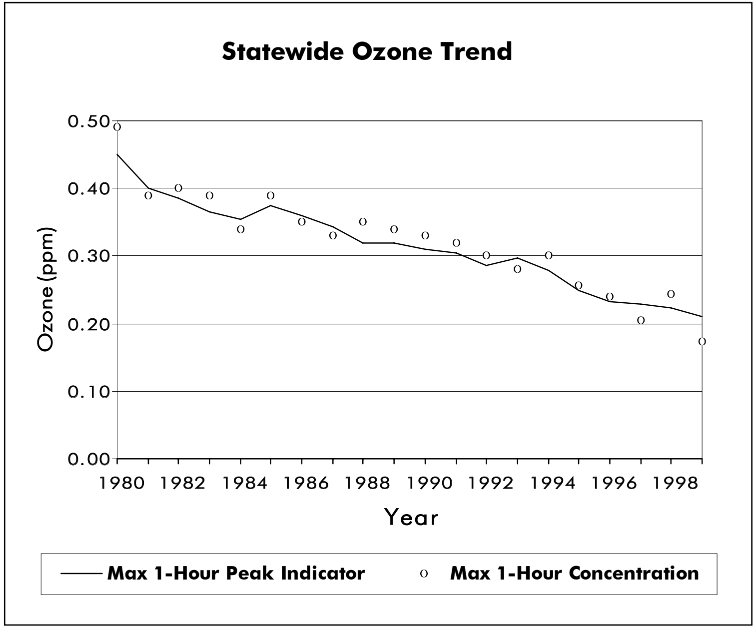

Figure 3-4

Population-Weighted Exposures for Ozone

There are a number of ways to look at how ozone levels in California have change over the years. Simple indicators such as the maximum concentration and number of days with concentrations above the level of a standard are commonly used. However, there are other, more complex indicators that provide additional insight into air quality. One of these is the population-weighted exposure indicator.

In contrast to the peak indicator, which provides an indication of the potential for acute adverse health impacts and is used elsewhere in this almanac, population-weighted exposure provides an indication of the potential for chronic adverse health impacts. It represents a composite of exposures at individual locations that are weighted to emphasize equally the exposure for each person in the area. This indicator is useful for tracking the progress in reducing the total annual exposure in an area because it incorporates both the level and the duration of the exposures. However, it represents the average exposure for all persons, not the peak exposure of those living in the area of the region's highest concentrations. The term "exposure" is used here in reference to the ambient outdoor ozone concentrations. In this context, exposure refers to the annual sum of the positive differences between all of the measured ozone concentrations and the State ozone standard. For example, a measured ozone concentration of 0.11 ppm for one hour represents an exposure of 0.02 ppm-hours above the State ozone standard of 0.09 ppm:

$$(0.11 \text{ ppm} - 0.09 \text{ ppm}) \times 1 \text{ hour} = 0.02 \text{ ppm-hours}$$

A measured concentration of 0.10 ppm for two hours also equals an exposure of 0.02 ppm-hours:

$$(0.10 \text{ ppm} - 0.09 \text{ ppm}) \times 2 \text{ hours} = 0.02 \text{ ppm-hours}$$

For the purposes of computing the exposure indicator, individuals are presumed to have been exposed to the concentrations measured by the ambient air quality monitoring network. Accordingly, the exposure indicator does not represent the potential for health effects for all individuals in an area, because daily activity patterns (for example, being inside a building or exercising outdoors) may diminish or increase exposures to some outdoor concentrations that exceed the State standard.

Unlike the peak indicator which tracks progress at individual locations, the population-weighted exposure indicator consolidates the hourly exposures at all sites into a single exposure value. The result is a value representing the average exposure in an area, which in this case, is an air basin or metropolitan area. The population-weighted exposures in Table 3-3 are listed for each year, from 1980 through 1999, for the five most populated areas of California: South Coast Air Basin, San Francisco Bay Area Air Basin, San Joaquin Valley Air Basin, San Diego Air Basin, and Sacramento Metropolitan Area. The calculations for the exposure indicators are based on all concentrations measured in the area that satisfy the specified data requirements. In addition, the calculations use census information for 1990. Complete details on the computational procedure can be found in the ARB publication entitled: "*Guidance for Using Air Quality-Related Indicators in Reporting Progress in Attaining the State Ambient Air Quality Standards*" (September 1993).

Population-Weighted Ozone Exposure (pphm-hr/person)																				
Area	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
South Coast Air Basin	1902.57	1647.98	1210.68	1881.67	1335.07	1566.63	1329.52	976.63	1064.77	967.91	588.02	671.70	685.99	453.47	474.60	525.34	222.36	88.57	190.18	33.82
San Francisco Bay Area Air Basin	48.21	13.91	6.54	48.13	33.45	15.86	6.03	27.21	11.22	5.01	2.57	1.86	2.51	4.63	1.54	18.58	5.20	0.71	6.00	5.87
San Joaquin Valley Air Basin	328.97	209.12	162.10	164.51	210.90	229.36	286.27	399.04	321.99	144.02	105.03	177.46	108.32	172.14	118.45	158.49	236.84	70.25	238.04	136.88
San Diego Air Basin	237.37	140.88	235.62	288.38	178.47	217.63	100.05	87.64	139.30	171.53	150.91	99.00	67.98	39.76	6.43	11.59	6.28	8.89	7.14	1.21
Sacramento Metro Area	135.54	160.15	64.30	79.30	124.93	112.86	92.04	118.01	189.82	24.76	44.02	85.30	56.32	28.92	27.72	76.47	64.40	6.01	75.28	44.66

Table 3-3

Ozone Transport

Since 1989, the ARB staff has evaluated the impacts of the transport of ozone and ozone precursor emissions from upwind areas to the ozone concentrations in downwind areas. These 12 years with analyses demonstrate that the air basin boundaries are not true boundaries of air masses. All urban areas are upwind contributors to their downwind neighbors with the exception of San Diego. Figure 3-5 shows the flow of pollutants throughout the State. The ozone problem in some rural areas is caused almost solely by transported pollutants. These areas, although designated as nonattainment, are not required to adopt an air quality plan because local control strategies in these areas would not be effective in reducing ozone concentrations. However, these areas are subject to many statewide control strategies, such as cleaner fuels and low emission vehicles. More detailed information about ozone transport is available on the web at: *www.arb.ca.gov/aqd/transport/transport.htm*.

Figure 3-5

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Particulate Matter (PM_{10})

Emission Trends and Forecasts - PM_{10}

The upward trend in statewide directly emitted PM_{10} emissions is primarily due to an increase in emissions from area-wide sources. This includes an increase in emissions of unpaved and paved road dust due to increases in vehicle miles traveled (VMT) over these roads. Exhaust emissions from diesel vehicles dropped by 60 percent from 1990 to 2000 due to more stringent emissions standards and the introduction of cleaner burning diesel fuel. PM_{10} emissions from stationary sources are expected to increase slightly in the future due to industrial growth.

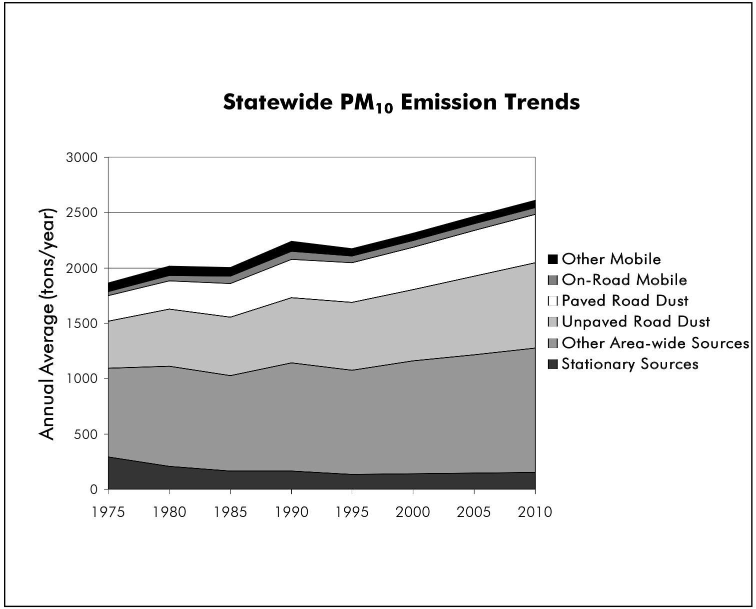

Figure 3-6

Emission Trends and Forecasts - PM_{10}

PM10 Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***1864***	***2017***	***2004***	***2240***	***2177***	***2313***	***2466***	***2612***
Stationary Sources	293	205	164	163	136	137	146	155
Area-wide Sources	1455	1680	1696	1915	1913	2051	2193	2332
Paved Road Dust	227	258	303	346	359	386	416	439
Unpaved Road Dust	429	514	531	591	617	644	706	773
Other Area-wide Sources	799	908	862	977	937	1021	1071	1120
On-Road Mobile	37	44	64	75	61	56	58	61
Gasoline Vehicles	23	21	25	30	33	38	44	49
Diesel Vehicles	14	24	39	45	27	18	14	12
Other Mobile	79	88	80	88	68	69	69	64

Table 3-4

Statewide Air Quality - PM_{10}

In contrast to ozone and carbon monoxide, PM_{10} concentrations do not relate as well to growth in population or vehicle usage, and high PM_{10} concentrations do not always occur in high population areas. Activities that contribute to high PM_{10} can include wood burning, agricultural activities, and driving on unpaved roads. Figure 3-7 shows the maximum statewide annual geometric mean PM_{10} concentrations from 1988 to 1999. The trend line reflects the South Coast Air Basin. The trend line shows a fairly steady decline over the trend period, reflecting an overall decrease of about 21 percent. The higher values in 1997 and 1999 may be due to meteorology rather than an increase in emissions, and therefore, may not signal a change in the overall trend. However, several more years of data are needed before making any judgement. Currently, over 99 percent of Californians breathe air that violates the State PM_{10} standards during at least part of the year. As a result, particulate matter is commanding greater attention, and much effort will be needed to attain the standards for this pollutant.

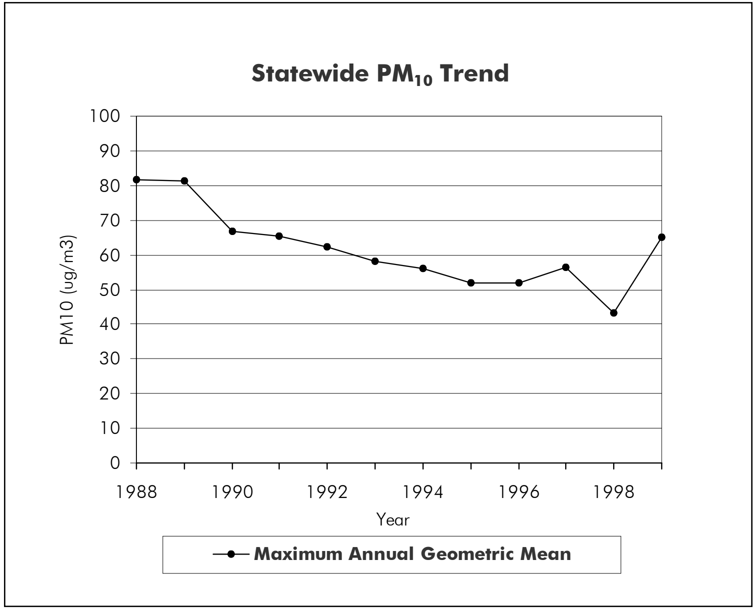

Figure 3-7

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Carbon Monoxide

Emission Trends and Forecasts - Carbon Monoxide

Since 1975, even though motor vehicle miles traveled (VMT) have continued to climb, the adoption of more stringent motor vehicle emissions standards has dropped statewide CO emissions from on-road motor vehicles by over 60 percent in 2000. With continued vehicle fleet turnover to cleaner vehicles including super ultra low emitting vehicles (SULEV's) and electric vehicles (EV's), and the incorporation of cleaner burning fuels, CO emissions are forecast to continue decreasing through the year 2010. CO emissions from other mobile sources are also projected to decrease through 2010 as more stringent emissions standards are implemented. CO emissions from area-wide sources are expected to increase slightly due to increased waste burning and additional residential fuel combustion resulting from population increases.

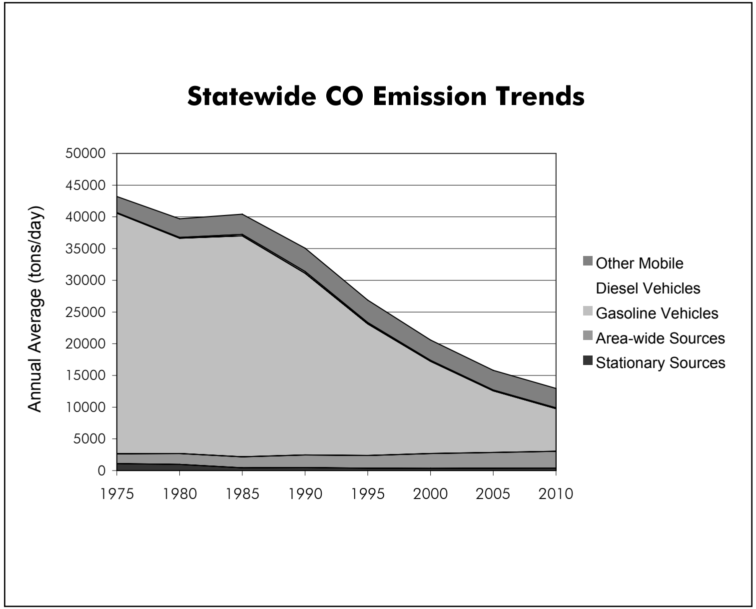

Figure 3-8

Emission Trends and Forecasts - Carbon Monoxide

CO Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***43210***	***39701***	***40427***	***35062***	***26870***	***20591***	***15802***	***12944***
Stationary Sources	1088	977	424	475	368	349	367	384
Area-wide Sources	1555	1719	1753	1980	2017	2343	2489	2651
On-Road Mobile	38022	34055	35064	28925	20951	14691	9848	6856
Gasoline Vehicles	37951	33931	34840	28656	20733	14538	9714	6738
Diesel Vehicles	71	125	224	269	219	153	134	118
Other Mobile	2545	2950	3185	3682	3533	3207	3098	3053

Table 3-5

Statewide Air Quality - Carbon Monoxide

Similar to ozone, carbon monoxide concentrations in all areas of California have decreased substantially over the last 20 years, despite significant growth. Statewide, the maximum peak 8-hour indicator declined 35 percent from 1980 to 1999. Currently, the State and national carbon monoxide standards are violated in only two areas: the South Coast Air Basin portion of Los Angeles County and the city of Calexico, in Imperial County. The introduction of cleaner fuels has helped bring the rest of the State into attainment. While cleaner fuels will have a continuing impact on carbon monoxide levels, additional emission reductions will be needed in the future to keep pace with increases in population and vehicle usage. These reductions will come from continued fleet turnover, expanded use of low emission vehicles, and measures to promote less polluting modes of transportation. In addition, the introduction of zero emission vehicles, such as the electric car, will play an increasingly important role in the coming years.

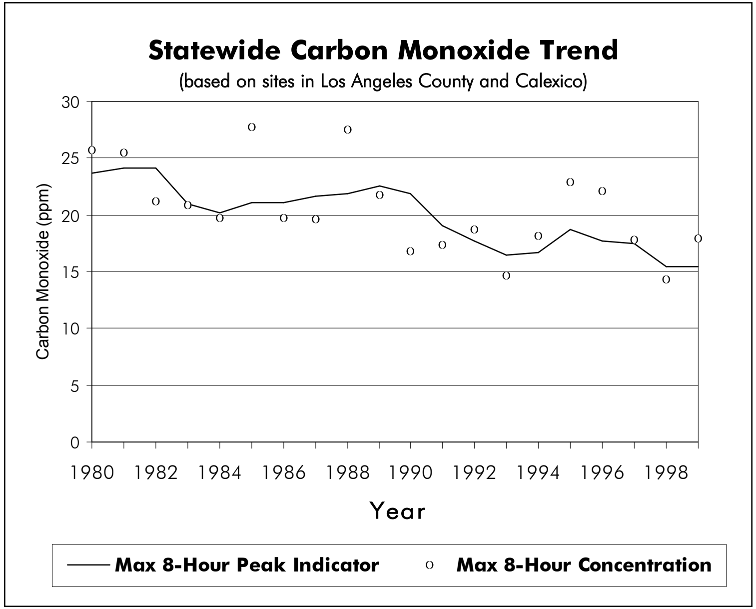

Figure 3-9

Success Stories

Statewide Air Quality - Lead

The decrease in lead emissions and ambient lead concentrations over the past 25 years is California's most dramatic success story. The rapid decrease in lead concentrations can be attributed primarily to phasing out the lead in gasoline. This phase-out began during the 1970s, and subsequent ARB regulations have virtually eliminated all lead from the gasoline now sold in California. All areas of the State are currently designated as attainment for the State lead standard (the United States Environmental Protection Agency does not designate areas for the national lead standard). Although the ambient lead standards are no longer violated, lead emissions from stationary sources still pose "hot spot" problems in some areas. As a result, the ARB identified lead as a toxic air contaminant in 1997.

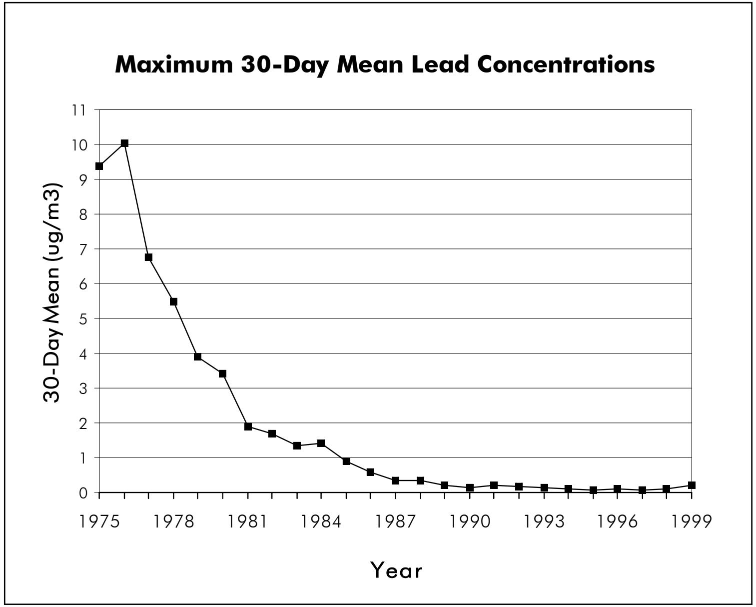

Figure 3-10

Nitrogen Dioxide

Emission Trends and Forecasts - Oxides of Nitrogen

Nitrogen dioxide (NO_2) is a colorless, tasteless gas that can cause lung damage, chronic lung disease, and respiratory infections. Nitrogen dioxide is a component of NO_x, and its presence in the atmosphere can be correlated with emissions of NO_x. Statewide emissions of NO_x are projected to decrease by almost 50 percent from 1985 to 2010 as a result of more stringent emissions standards for stationary source combustion and motor vehicles, and cleaner burning fuels. The introduction of lower emitting vehicles will continue to further reduce NO_x emissions.

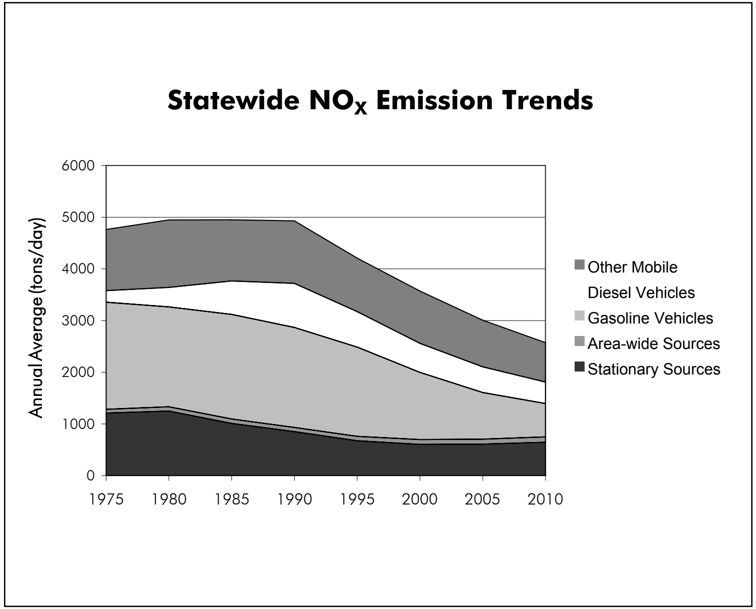

Figure 3-11

Emission Trends and Forecasts - Oxides of Nitrogen

NOx Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***4761***	***4947***	***4950***	***4929***	***4207***	***3570***	***3007***	***2573***
Stationary Sources	1209	1249	1010	849	673	603	607	644
Area-wide Sources	72	81	84	81	85	94	99	104
On-Road Mobile	2299	2310	2670	2787	2413	1862	1397	1061
Gasoline Vehicles	2074	1933	2024	1934	1728	1301	902	647
Diesel Vehicles	224	378	647	853	686	561	495	415
Other Mobile	1181	1306	1185	1211	1035	1011	904	763

Table 3-6

Statewide Air Quality - Nitrogen Dioxide

Oxides of nitrogen (NO_x) emissions are a by-product of combustion from both mobile and stationary sources, and they contribute to ambient nitrogen dioxide (NO_2) concentrations. Since 1975, maximum NO_2 concentrations have decreased more than 50 percent, due primarily to the implementation of tighter controls on both mobile and stationary sources. Although many of these controls were implemented to reduce ozone, they also benefited NO_2. All areas of California are currently designated as attainment for the State standard and unclassified/attainment for the national nitrogen dioxide standard. Projections show NO_x emissions will continue to decline, thereby assuring continued attainment.

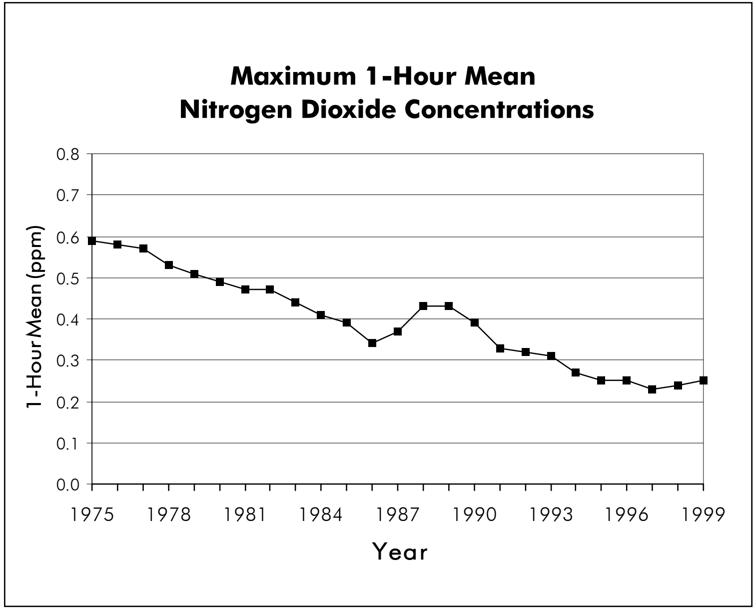

Figure 3-12

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Sulfur Dioxide

Emission Trends and Forecasts - Oxides of Sulfur

SO_x (oxides of sulfur) is a group of compounds of sulfur and oxygen. A major constituent of SO_x is sulfur dioxide (SO_2). Emissions of SO_x declined tremendously in California between 1975 and 2000. Emissions in 2000 are about 75 percent less than emissions in 1975. Sulfur dioxide emissions from stationary sources were decreased between 1975 and 2000 due to improved industrial source controls and switching from fuel oil to natural gas for electric generation and industrial boilers. The SO_x emissions from both gasoline and diesel vehicle exhaust have also decreased due to lower sulfur content in the fuel.

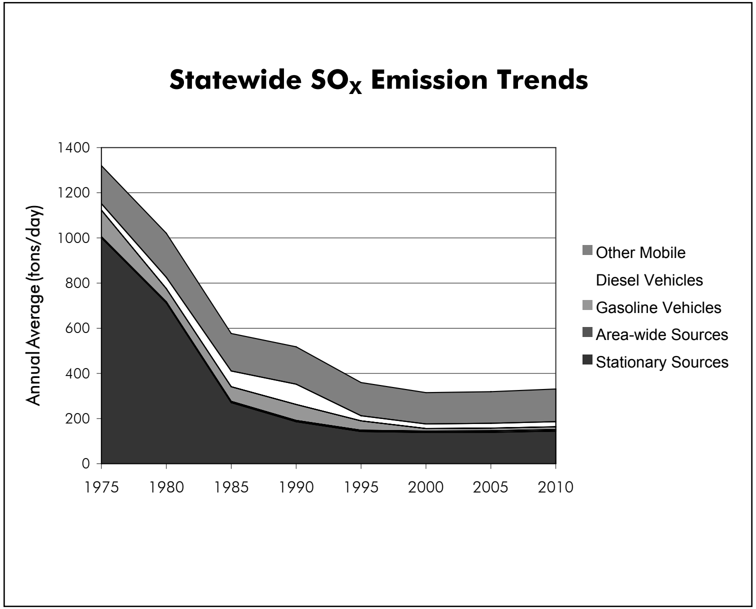

Figure 3-13

Emission Trends and Forecasts - Oxides of Sulfur

SO_x Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***1320***	***1021***	***577***	***518***	***360***	***315***	***319***	***331***
Stationary Sources	1001	713	271	186	143	139	140	144
Area-wide Sources	4	5	5	5	5	6	6	7
On-Road Mobile	147	108	135	161	65	31	33	35
Gasoline Vehicles	118	58	65	71	42	11	12	13
Diesel Vehicles	29	50	70	90	23	20	21	23
Other Mobile	168	195	166	165	147	139	140	144

Table 3-7

Statewide Air Quality - Sulfur Dioxide

Similar to oxides of nitrogen, oxides of sulfur (SO_x) emissions come from both mobile and stationary sources. These SO_x emissions contribute to ambient sulfur dioxide (SO_2) concentrations. While SO_2 poses significant problems in other parts of the nation, SO_x emissions in California have been reduced sufficiently over the last 25 years so that all areas of California now attain the State standards for sulfur dioxide. Many of the major urban areas are also designated as attainment for the national sulfur dioxide standards. However, most of California is designated as unclassified. With current and anticipated SO_x emission control measures, all areas of the State are expected to remain attainment for SO_2.

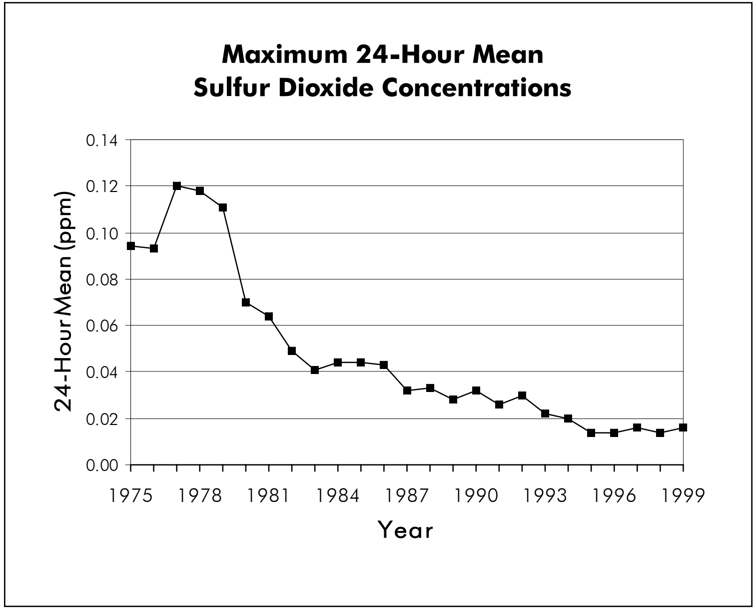

Figure 3-14